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<b>(21) International Application Number:</b> PCT/US96/16405 <b>(22) International Filing Date:</b> 15 October 1996 (15.10.96)  <b>(30) Priority Data:</b> 542,494 13 October 1995 (13.10.95) US  <b>(71) Applicant:</b> W.R. GRACE & CO.-CONN. [US/US]; 100 Rogers Bridge Road, P.O. Box 464, Duncan, SC 29334 (US).  <b>(72) Inventors:</b> KUO, Betsy, P.; 6/12-18 Otter Street, Collingwood, VIC 3066 (AU). WALDEN, Mendy, J.; 119 Piedmont Dairy Road, Moore, SC 29309 (US).  <b>(74) Agents:</b> HURLEY, Rupert, B., Jr. et al.; W.R. Grace & Co. - Conn., Legal Services Group, 100 Rogers Bridge Road, P.O. Box 464, Duncan, SC 29334 (US).		<b>(81) Designated States:</b> AU, BR, CA, CN, JP, MX, NZ, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).  <b>Published</b> <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
<b>(54) Title:</b> OXYGEN-PERMEABLE MULTILAYER FILM CONTAINING ANTIFOG AGENT, PACKAGING PROCESS USING SAME, AND PACKAGED PRODUCT COMPRISING SAME		
<b>(57) Abstract</b>  A multilayer film comprises: a first layer comprising a first homogeneous ethylene/alpha-olefin copolymer, a second layer comprising a polyolefin; and a third layer comprising a second homogeneous ethylene/alpha-olefin copolymer. The second layer is between the first layer and the third layer, the second layer is chemically different from the first layer and the third layer, and the multilayer film has an O <sub>2</sub> -transmission rate of from about 500 to 50,000 cc/m <sup>2</sup> /24hr STP. One outer layer of the film comprises an antifog agent on the outer surface thereof. Also disclosed are a packaging process using the film, and a product packaged in the film. The film is especially suitable for the packaging of oxygen-sensitive products, such as lettuce, and resists fogging up on the inside surface of the film forming the package. Preferably, the package has printing on the outside surface of the film, with the print having good adhesion to the film.		

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OXYGEN-PERMEABLE MULTILAYER FILM CONTAINING ANTIFOG AGENT,  
PACKAGING PROCESS USING SAME,  
AND PACKAGED PRODUCT COMPRISING SAME

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Cross-Reference to Related Application

This application is a continuation-in-part of co-pending U.S. Patent Application Serial Number 08/218,776, filed March 28, 1994, in the name of Betsy P. Kuo.

Field of the Invention

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The present invention relates to multi-layer films, particularly multi-layer films suitable for use as packaging films. The present invention is also directed to packaging processes, and packaged products. The present invention is particularly related to films suitable for packaging oxygen-sensitive products, such as lettuce, wherein the film has an surface active agent thereon which serves as an antifog agent.

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Background of the Invention

Multilayer films have been utilized for the packaging of "oxygen-sensitive products", such as lettuce, i.e., products which exhibit lower shelf life in the presence of either too much oxygen in the package, or too little oxygen in the package. In such multilayer films used for packaging oxygen-sensitive products, the O<sub>2</sub>-transmission rate, and even the carbon dioxide transmission rate, are of primary importance, especially in the packaging of such oxygen-sensitive products as vegetables, fruits, and cheese. For example, in the packaging of precut lettuce, the presence of too much oxygen in the package results in enzymatic browning of cut surfaces, known as pink ribbing. On the other hand, if the concentration of oxygen in the package is too low, the lettuce tends to spoil due to anaerobiosis.

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Cut lettuce is frequently packaged using vertical form fill and seal (VFFS) equipment. Produce packaging films used on VFFS equipment have been composed from a variety of materials, including polyethylene, ethylene/vinyl acetate copolymer, ethylene/methyl acrylate copolymer, blends of polyethylene and ethylene/vinyl acetate copolymer, and polypropylene. Such films are typically multilayer films.

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Furthermore, different products, such as lettuce and broccoli, exhibit maximum shelf-life when packaged in films having O<sub>2</sub>-transmission rates substantially different from one another. There are many O<sub>2</sub>-sensitive products having a shelf-life which is dependent upon the O<sub>2</sub>-transmission rate of the package within which they are contained, and the optimum O<sub>2</sub>-transmission rates for the packaging of

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these products varies widely. As a result, it is desirable to provide a process for producing a variety of multilayer films having differing O<sub>2</sub>-transmission rates.

Gas transmission rates for vegetable packaging films have traditionally been tailored to a desired level by varying the overall thickness of the multilayer film. That is, in order to achieve a desired, relatively high O<sub>2</sub>-transmission rate, a thinner film is produced. Such downgauging is often done at the expense of film strength and abuse resistance. Conversely, film structures which are abuse-resistant and machinable generally lack the desired level of gas permeability and sealing properties required for such applications as use in vertical form fill and seal equipment. It is therefore desirable to provide a film which combines abuse resistance with a relatively high O<sub>2</sub>-transmission rate.

Moreover, it would be desirable to utilize a film structure and composition which permits structural and compositional changes so that a set of multilayer films of a substantially singular thickness exhibit a relatively wide spectrum of O<sub>2</sub>-transmission rates and CO<sub>2</sub>-transmission rates. In this manner, overall film physical properties can be kept substantially constant, while at the same time films can be tailored to the optimal O<sub>2</sub>-transmission rates and the optimal carbon dioxide transmission rates of a variety of O<sub>2</sub>-sensitive products.

Furthermore, it would be advantageous to provide such a film with a composition and structure which has desirable sealing characteristics, i.e., does not exhibit burn through, does not pucker at the seal, exhibits good hot tack, and seals quickly and at relatively low temperature, while simultaneously permitting optimization of oxygen and carbon dioxide transmission rates, via the ability to vary the structure and composition of the multilayer film, without substantially increasing or substantially decreasing the overall thickness of the multilayer film.

It is also important for multilayer films used in vertical form fill and seal equipment to have surface layers sealable with hot bar and impulse type sealing systems. Other desirable attributes are abuse resistance, clarity, and a modulus sufficient that the film has good machinability on vertical form fill and seal equipment.

Prior art films useful for the packaging of O<sub>2</sub>-sensitive products have been found to lack the combination of desirable OTR for maximum shelf life, machinability properties to run on vertical form fill and seal equipment, high hot tack strength, as well as optical properties such as high gloss and low haze.

Films used on vertical form fill and seal (VFFS) equipment are subjected to at least two different kinds of seals being produced during the packaging of the product, i.e., a longitudinal or vertical seal, and horizontal bottom and top seals. Accordingly, in the construction of such packages, characteristics such

as the temperature required to form the seal, adequate heat-resistance to prevent burn through, and a very high percentage of continuous (nondefective) seals, are all important in assessing the performance of any given film for the packaging of O<sub>2</sub>-sensitive products.

5 Fogging of the package is also a common problem in the packaging of produce and other food products. It would be desirable to provide a package comprising a film which resists fogging, in order to provide the consumer with a clear view of the contents of the package, and in order to provide a more aesthetically appealing package, especially in retail applications where product presentation is important. However, surface active agents which are effective antifog agents tend to interfere with ink adhesion to the film. This detrimental effect occurs because the antifog agent blooms to the outside surface of the  
10 package and interferes with the adhesion of the ink to the film. This detriment is significant for packages designed for consumer end use, as the consumer does not find such a package to be appealing if the ink is smeared or if the ink comes off onto other articles or the consumer. Thus, it would be especially desirable to provide a film having a desired O<sub>2</sub>-transmission rate suitable for the packaging of various products, wherein the film further comprises an antifog agent on an outer film surface which forms the  
15 inside surface of the package, while also providing adequate adhesion for printing on an outer surface of the film, which outer surface serves as the outside surface of the package.

#### Summary of the Invention

20 The multilayer packaging film of the present invention has desirable sealing characteristics, does not exhibit burn through, does not pucker at the seal, provides a very desirable level of hot tack strength, and has a desirable O<sub>2</sub>-transmission rate and a desirable CO<sub>2</sub>-transmission rate, while simultaneously providing very desirable optical properties, i.e., high gloss and low haze, and while also providing an antifog agent on an outer surface of the film.

25 An especially preferred film according to the present invention has the antifog present on a first outer film surface, and printing on a second outer surface, with the printing being securely adhered to the second outer surface, i.e., so that the printing will not rub off of the package. It has been found that if too much antifog agent is used relative to film thickness, the antifog will bloom to the second outer surface of the film, which is to be printed, in an amount which reduces ink adhesion. It has also been discovered that the application of corona treatment at extrusion, i.e., before the antifog agent can bloom to the far  
30 outer surface of the film, results in a film having enhanced ink adhesion relative to a film which is corona treated on the printer, i.e., after blooming to the far outer surface has occurred. It has also been found

that if the antifog agent is present in the film in an amount above about 2 percent, based on the weight of the entire film, the antifog agent will bloom to the far surface of the film, and interfere with print adhesion.

Furthermore, using the multilayer film of the present invention in VFFS equipment results in packages having a very low percentage of "leakers", i.e., packages having a defective seal. The desirable processing characteristics of the multilayer film of the present invention enable greater packaging speeds on VFFS equipment, as well as other packaging machinery. These desirable processing characteristics extend to other packaging operations in which the film is used as lidstock, overwrap, etc. The greater packaging speeds are due to the low seal temperature and high hot tack strength characteristics of the multilayer film of the present invention.

As a first aspect, the present invention pertains to a multilayer film comprising a first outer layer, at least one inner film layer, and a second outer layer. The first outer layer comprises: (i) a polymeric component comprising at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer; and (ii) a surface-active agent component comprising at least one member selected from the group consisting of ester of aliphatic alcohol, polyether, polyhydric alcohol, ester of polyhydric aliphatic alcohol, and polyethoxylated aromatic alcohol. At least one of the inner layer(s) comprises polyolefin. The second outer layer comprises at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer. The surface-active component is present over the entire outside surface of the first outer layer. The inner layer is between the first outer layer and the second outer layer, and the inner layer is chemically different from the first outer layer and the second outer layer. The multilayer film has an O<sub>2</sub>-transmission rate of from about 500 to 50,000 cc/m<sup>2</sup> 24hr STP.

Preferably, the multilayer film further comprises printing on an outer surface of the second outer layer, which has an outer surface having a surface tension of at least 38 dynes; more preferably, from about 38 to 50 dynes; more preferably, from about 40 to 48 dynes; still more preferably, from about 42 to 46 dynes. Preferably, the outer surface of the second outer layer is substantially free of a surface-active agent. Preferably, the printing is adhered to the film to a level of at least about 80 percent, as measured by a standard tape test disclosed hereinbelow.

Preferably, the multilayer film has an O<sub>2</sub>-transmission rate of from about 1000 to 20,000 cc/m<sup>2</sup> 24hr STP; more preferably, from about 2,000 to 10,000 cc/m<sup>2</sup> 24hr STP; still more preferably, from about 3,000 to 6,000 cc/m<sup>2</sup> 24hr STP.

Preferably, at least one inner layer has a modulus higher than the first outer layer modulus. More preferably, at least one inner layer has a modulus higher than the second outer layer modulus. Preferably, the first outer layer has a modulus of from about 5,000 to 50,000 psi; more preferably, from about 15,000 to 45,000; still more preferably, from about 20,000 to 40,000 psi. Preferably, the second outer layer has a modulus of from about 30,000 to 500,000 psi; more preferably, from about 50,000 to 300,000 psi; and still more preferably, from about 100,000 to 200,000 psi. Preferably, at least one inner layer has a modulus of from about 15,000 to 45,000 psi; more preferably, from about 20,000 to 40,000 psi; still more preferably, from about 20,000 to 40,000 psi. Preferably, the film has a total film modulus of at least 40,000 psi, more preferably, from about 50,000 to 150,000 psi; still more preferably, from about 80,000 to 110,000 psi

Preferably, the first outer layer comprises homogeneous ethylene/alpha-olefin copolymer, and the surface-active agent comprises at least one member selected from the group consisting of polyoxyethylene (20) sorbitan monostearate, polyoxyethylene (20) sorbitan monolaurate, polyoxyethylene (20) monopalmitate, polyoxyethylene (20) sorbitan tristearate, polyoxyethylene (20) sorbitan trioleate, poly(oxypropylene), polyethoxylated fatty alcohol, and polyoxyethylated 4-nonylphenol, polyhydric alcohol, propylene diol, propylene triol, and ethylene diol. Preferably, the surface active agent is present in the first layer in an amount of from about 0.25 to 2.0 weight percent, based on the weight of the entire multilayer film; more preferably, from about 0.5 to 1.5 weight percent; and, still more preferably, from about 0.5 to 1.0 weight percent. Preferably, the antifog is present throughout the entire first outer layer, e.g., is present in a blend which is extruded to form the first outer layer.

Preferably, the first outer layer comprises a first homogeneous ethylene/alpha-olefin copolymer, and the second outer layer comprises a second homogeneous ethylene/alpha-olefin copolymer. Preferably, the first homogeneous ethylene/alpha-olefin copolymer has a density of less than about 0.915 grams per cubic centimeter; more preferably, from about 0.850 to 0.915 g/cc; still more preferably, from about 0.88 to 0.912; and yet still more preferably, from about 0.902 to 0.908. Preferably, the second homogeneous ethylene/alpha-olefin copolymer has a density of less than about 0.915 grams per cubic centimeter; more preferably, from about 0.85 to 0.915 g/cc; still more preferably from about 0.88 to 0.912; and yet still more preferably, from about 0.902 to 0.908.

Preferably, the first homogeneous ethylene/alpha-olefin copolymer has a melting point of up to 110°C; more preferably, from about 65 to 110°C; still more preferably, from about 85 to 110°C; and yet still more preferably, from about 95 to 105°C. Preferably, the second homogeneous ethylene/alpha-

olefin copolymer has a melting point of up to 110°C; more preferably, from about 65 to 110°C; still more preferably, from about 85 to 110°C; and yet still more preferably, from about 95 to 105°C.

Preferably, at least one inner film layer comprises at least one member selected from the group consisting of ethylene homopolymer, propylene homopolymer, ethylene/alpha-olefin copolymer, propylene/ethylene copolymer, ethylene/unsaturated ester copolymer, styrene homopolymer, styrene copolymer, and ethylene cycloolefin copolymer.

Preferably, the first homogeneous ethylene/alpha-olefin copolymer comprises a copolymer resulting from the copolymerization of from about 99 to 80 weight percent ethylene, based on total monomer weight, and from about 1 to 20 weight percent of a first alpha-olefin, based on total monomer weight, wherein the first alpha-olefin comprises at least one member selected from the group consisting of butene, hexene, and octene; more preferably, the first homogeneous ethylene/alpha-olefin copolymer consists essentially of a copolymer resulting from the copolymerization of from about 95 to 85 weight percent ethylene, based on total monomer weight, and from about 5 to 15 weight percent of a first alpha-olefin, based on total monomer weight, wherein the first alpha-olefin comprises a member selected from the group consisting of octene-1, and a blend of hexene-1 and butene-1.

Preferably, at least one inner layer comprises at least one member selected from the group consisting of polypropylene homopolymer and propylene/ethylene copolymer containing from about 0.1 to 6 weight percent ethylene; more preferably, the inner layer comprises a propylene/ethylene copolymer containing from about 0.1 to 6 weight percent ethylene, the propylene/ethylene copolymer being present in an amount of at least 50 weight percent, based on the weight of the inner layer.

Preferably, the second homogeneous ethylene/alpha-olefin copolymer comprises a copolymer resulting from the copolymerization of from about 99 to 80 weight percent ethylene, based on total monomer weight, and from about 1 to 20 weight percent of a second alpha-olefin, based on total monomer weight, wherein the second alpha-olefin comprises at least one member selected from the group consisting of butene-1, hexene-1, and octene-1; more preferably, the second homogeneous ethylene/alpha-olefin copolymer consists essentially of a copolymer resulting from the copolymerization of from about 95 to 85 weight percent ethylene, based on total monomer weight, and from about 5 to 15 weight percent of a second alpha-olefin, based on total monomer weight, wherein the second alpha-olefin comprises a member selected from the group consisting of octene-1, and a blend of hexene-1 and butene-1.

Preferably the multilayer film has three layers. Preferably, the first outer layer makes up from about 10 to 80 weight percent of the multilayer film; more preferably, from about 10 to 40 weight percent.



Preferably, the inner layer makes up from about 10 to 80 weight percent of the multilayer film; more preferably, from about 20 to 80 weight percent. Preferably, the second outer layer makes up from about 10 to 80 weight percent of the multilayer film; more preferably, from about 10 to 40 weight percent.

5 Preferably, the outer surface of the second film layer, i.e., the surface of the second outer film layer which is an outer surface of the film, is "substantially free of surface-active agent". As used herein, this phrase refers to the outer surface of the second layer as being produced completely free of antifog agent, but being susceptible of a minor level of antifog agent contamination from adjacent wraps of the film on a core.

10 Preferably, the multilayer film has three layers and a total thickness of from about 1 to 3 mils; more preferably, from about 1 to 2.5 mils; and still more preferably, from about 1.5 to 2 mils. Preferably, the first outer layer having a thickness of about 0.3 to 0.8 mil; more preferably, from about 0.4 to 0.5 mils. Preferably, the inner layer has a thickness of from about 0.5 to 1 mil; more preferably, from about 0.6 to 0.8 mil. Preferably, the second outer layer having a thickness of from about 0.3 to 0.8 mil; more preferably, from about 0.4 to 0.5 mil. Preferably, the inner layer comprises a propylene/ethylene  
15 copolymer containing from about 2 to 5 weight percent ethylene. Preferably, the first homogeneous ethylene alpha-olefin copolymer is substantially identical to the second homogeneous ethylene alpha-olefin copolymer.

As a second aspect, the present invention pertains to a packaging process for packaging an O<sub>2</sub>-sensitive product, comprising: (a) supplying, to a vertical form fill and seal apparatus, a rollstock  
20 comprising a multilayer film; (b) forming a substantially vertically-oriented tube from the multilayer film, by passing the film over a collar member of the vertical form fill and seal apparatus, so that substantially vertically-oriented edge portions of the film are adjacent one another; (c) forming a longitudinal seal along at least a segment of the adjacent edge portions of the film, to form a sealed tube segment; (d) collapsing a lower end portion of the sealed tube segment, and forming a bottom package seal across the collapsed  
25 lower end portion of the sealed tube segment, to form a pouch; (e) adding an appropriate quantity of the O<sub>2</sub>-sensitive product to the pouch; and (f) collapsing an upper end portion of the pouch, and forming a top package seal across the collapsed upper end portion to form a sealed pouch containing the oxygen-sensitive product, whereby a package is formed. The film is as described above, i.e., according to the first aspect of the present invention, and preferred films are also as described above.

30 In one preferred embodiment of the process, the O<sub>2</sub>-sensitive product comprises a cut vegetable comprising at least one member selected from the group consisting of lettuce, cabbage, broccoli, green beans, cauliflower, spinach, kale, carrot, onion, radish, endive, and escarole. In another preferred

embodiment of the process, the O<sub>2</sub>-sensitive product comprises a cut vegetable comprising at least one member selected from the group consisting of lettuce, cabbage, green beans, kale, carrot, onion, radish, endive, and escarole, and the multilayer film has an oxygen permeability of from about 3,000 to 6,000 cc/m<sup>2</sup>/ 24hr STP.

5 In the packaging process according to the present invention, preferably the vertical form fill and seal machine forms, fills, and seals at least 15 packages per minute, without substantial burn-through of the film at the seals. Preferably, the film is sealed at a temperature of from about 70°C to 150°C, and the film exhibits a hot tack strength of from about 4 to 15 Newtons.

10 As a third aspect, the present invention pertains to a package comprising an O<sub>2</sub>-sensitive product, and a multilayer film surrounding the product. The film is as described above, i.e., according to the first aspect of the present invention, and preferred films are also as described above.

As a fourth aspect, the present invention pertains to a process for heating a package comprising a food product, the process comprising: (a) packaging the food product in a film, and (b) heating the food product and film to a temperature of from about 80°F to 212°F, for a period of from about 1 to 60 minutes. The food product is substantially encased by the film, and the film survives heating without substantial loss of package integrity, i.e., that the package maintains a hermetic seal of the product therein. The film is as described above, i.e., according to the first aspect of the present invention, and preferred films are also as described above. Preferably, the heating is carried out for a period of from about 1 to 30 minutes; more preferably, from about 1 to 15 minutes; still more preferably, from about 1 to 10 minutes. Preferably, the food product is cooked during heating.

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#### Brief Description of the Drawings

Figure 1 illustrates an enlarged cross-sectional view of a three-layer multilayer film of the present invention.

25 Figure 2 illustrates an enlarged cross-sectional view of a five-layer multilayer film according to the present invention.

Figure 3 illustrates a schematic view of a process according to the present invention.

Figure 4 illustrates a vertical form fill and seal apparatus to be used in packaging process according to the present invention.

30 Figure 5 illustrates a packaged product of the present invention, the product being packaged in the multilayer film of the present invention.

Detailed Description of the Invention

As used herein, the term "monomer" refers to a relatively simple compound, usually containing carbon and of low molecular weight, which can react to form a polymer by combination with itself or with other similar molecules or compounds.

As used herein, the term "comonomer" refers to a monomer which is copolymerized with at least one different monomer in a copolymerization reaction, the result of which is a copolymer.

As used herein, the term "polymer" refers to the product of a polymerization reaction, and is inclusive of homopolymers, copolymers, terpolymers, etc.

As used herein, the term "homopolymer" is used with reference to a polymer resulting from the polymerization of a single monomer, i.e., a polymer consisting essentially of a single type of repeating unit.

As used herein, the term "copolymer" refers to polymers formed by the polymerization reaction of at least two different monomers. For example, the term "copolymer" includes the copolymerization reaction product of ethylene and an alpha-olefin, such as 1-hexene. However, the term "copolymer" is also inclusive of, for example, the copolymerization of a mixture of ethylene, propylene, 1-hexene, and 1-octene.

As used herein, the term "copolymerization" refers to the simultaneous polymerization of two or more monomers.

As used herein, a copolymer identified in terms of a plurality of monomers, e.g., "propylene/ethylene copolymer", refers to a copolymer in which the first listed monomer copolymerizes in a higher weight percent than the second listed monomer, and, for copolymers which are terpolymers, the first monomer copolymerizes in a higher weight percent than the second monomer, and the second monomer copolymerizes in a higher weight percent than the third monomer, etc.

As used herein, terminology employing a "/" with respect to the chemical identity of a copolymer (e.g., "an ethylene/alpha-olefin copolymer"), identifies the comonomers which are copolymerized to produce the copolymer. This terminology, as used herein, refers to the primary comonomer first, followed by the secondary comonomer. The copolymerization is carried out in the presence of more (on a weight percent basis) of the primary comonomer than the secondary comonomer.

As used herein, the phrase "heterogeneous polymer" refers to polymerization reaction products of relatively wide variation in molecular weight and relatively wide variation in composition distribution,

i.e., polymers made, for example, using conventional Ziegler-Natta catalysts. Such polymers typically contain a relatively wide variety of chain lengths and comonomer percentages.

As used herein, the phrase "heterogeneous catalyst" refers to a catalyst suitable for use in the polymerization of heterogeneous polymers, as defined above. Heterogeneous catalysts are comprised of several kinds of active sites which differ in Lewis acidity and steric environment. Ziegler-Natta catalysts are heterogeneous catalysts. Examples of Ziegler-Natta heterogeneous systems include metal halides activated by an organometallic co-catalyst, such as titanium chloride, optionally containing magnesium chloride, complexed to trialkyl aluminum and may be found in patents such as U.S. Patent No. 4,302,565, to GOEKE, et al., and U.S. Patent No. 4,302,566, to KAROL, et al., both of which are hereby incorporated, in their entireties, by reference thereto.

As used herein, the phrase "homogeneous polymer" refers to polymerization reaction products of relatively narrow molecular weight distribution and relatively narrow composition distribution. Homogeneous polymers are useful in various layers of the multilayer film used in the present invention. Homogeneous polymers exhibit a relatively even sequencing of comonomers within a chain, the mirroring of sequence distribution in all chains, and the similarity of length of all chains, and are typically prepared using metallocene, or other single-site type catalysis.

More particularly, homogeneous ethylene/alpha-olefin copolymers may be characterized by one or more methods known to those of skill in the art, such as molecular weight distribution ( $M_w/M_n$ ), composition distribution breadth index (CDBI), and narrow melting point range and single melt point behavior. The molecular weight distribution ( $M_w/M_n$ ), also known as polydispersity, may be determined by gel permeation chromatography. The homogeneous ethylene/alpha-olefin copolymers useful in this invention will have a ( $M_w/M_n$ ) of less than 2.7. Preferably, the ( $M_w/M_n$ ) will have a range of about 1.9 to 2.5. More preferably, the ( $M_w/M_n$ ) will have a range of about 1.9 to 2.3. The composition distribution breadth index (CDBI) of such homogeneous ethylene/alpha-olefin copolymers will generally be greater than about 70 percent. The CDBI is defined as the weight percent of the copolymer molecules having a comonomer content within 50 percent (i.e., plus or minus 50%) of the median total molar comonomer content. The CDBI of linear polyethylene, which does not contain a comonomer, is defined to be 100%. The Composition Distribution Breadth Index (CDBI) is determined via the technique of Temperature Rising Elution Fractionation (TREF). CDBI determination clearly distinguishes the homogeneous copolymers used in the present invention (narrow composition distribution as assessed by CDBI values generally above 70%) from heterogeneous polymers such as VLDPEs available commercially which generally have a broad composition distribution as assessed by CDBI values generally less than 55%.

The CDBI of a copolymer is readily calculated from data obtained from techniques known in the art, such as, for example, temperature rising elution fractionation as described, for example, in Wild et. al., J. Poly. Sci. Poly. Phys. Ed., Vol. 20, p.441 (1982). Preferably, the homogeneous ethylene/alpha-olefin copolymers have a CDBI greater than about 70%, i.e., a CDBI of from about 70% to 99%. In general, the homogeneous ethylene/alpha-olefin copolymers in the multilayer films of the present invention also exhibit a relatively narrow melting point range, in comparison with "heterogeneous copolymers", i.e., polymers having a CDBI of less than 55%. Preferably, the homogeneous ethylene/alpha-olefin copolymers exhibit an essentially singular melting point characteristic, with a peak melting point ( $T_m$ ), as determined by Differential Scanning Colorimetry (DSC), of from about 60°C to 110°C. Preferably, the homogeneous copolymer has a DSC peak  $T_m$  of from about 90°C to 110°C. As used herein, the phrase "essentially single melting point" means that at least about 80%, by weight, of the material corresponds to a single  $T_m$  peak at a temperature within the range of from about 60°C to 110°C, and essentially no substantial fraction of the material has a peak melting point in excess of about 115°C., as determined by DSC analysis. DSC measurements are made on a Perkin Elmer System 7 Thermal Analysis System. Melting information reported are second melting data, i.e., the sample is heated at a programmed rate of 10°C./min. to a temperature below its critical range. The sample is then reheated (2nd melting) at a programmed rate of 10°C./min.

A homogeneous ethylene/alpha-olefin copolymer can, in general, be prepared by the copolymerization of ethylene and any one or more alpha-olefin. Preferably, the alpha-olefin is a  $C_3$ - $C_{20}$   $\alpha$ -monoolefin, more preferably, a  $C_4$ - $C_{12}$   $\alpha$ -monoolefin, still more preferably, a  $C_4$ - $C_8$   $\alpha$ -monoolefin. Still more preferably, the alpha-olefin comprises at least one member selected from the group consisting of butene-1, hexene-1, and octene-1, i.e., 1-butene, 1-hexene, and 1-octene, respectively. Most preferably, the alpha-olefin comprises octene-1, and/or a blend of hexene-1 and butene-1.

Processes for preparing homogeneous polymers are disclosed in U.S. Patent No. 5,206,075, U.S. Patent No. 5,241,031, and PCT International Application WO 93/03093, each of which is hereby incorporated by reference thereto, in its entirety. Further details regarding the production and use of one genus of homogeneous ethylene/alpha-olefin copolymers are disclosed in U.S. Patent No. 5,206,075, to HODGSON, Jr.; U.S. Patent No. 5,241,031, to MEHTA; PCT International Publication Number WO 93/03093, in the name of Exxon Chemical Company; PCT International Publication Number WO 90/03414, in the name of Exxon Chemical Patents, Inc., all four of which are hereby incorporated in their entireties, by reference there. Still another genus of homogeneous ethylene/alpha-olefin copolymers is

disclosed in U.S. Patent No. 5,272,236, to LAI, et. al., and U.S. Patent No. 5,278,272, to LAI, et. al., both of which are hereby incorporated in their entireties, by reference thereto.

As used herein, the term "polyolefin" refers to any polymerized olefin, which can be linear, branched, cyclic, aliphatic, aromatic, substituted, or unsubstituted.

5 As used herein, the phrases "inner layer" and "internal layer" refer to any film having its two principal surfaces with other layers of the multilayer film.

As used herein, the phrase "outer layer" refers to any film layer, of a multilayer film, having only one of its principal surfaces directly adhered to another layer of the film.

10 As used herein, the phrase "directly adhered", as applied to film layers, is defined as adhesion of the subject film layer to the object film layer, without a tie layer, adhesive, or other layer therebetween. In contrast, as used herein, the word "between", as applied to a film layer expressed as being between two other specified layers, includes both direct adherence of the subject layer between to the two other layers it is between, as well as including a lack of direct adherence to either or both of the two other layers the subject layer is between, i.e., one or more additional layers can be imposed between the subject layer and one or more of the layers the subject layer is between.

15 As used herein, the term "core", and the phrase "core layer", as applied to multilayer films, refer to any internal film layer which has a primary function other than serving as an adhesive or compatibilizer for adhering two layers to one another. Usually, the core layer or layers provide the multilayer film with a desired level of strength, i.e., modulus.

20 As used herein, the phrase "sealant layer", with respect to multilayer films, refers to an outer film layers, which are involved in the sealing of the film to itself or another layer. Although the phrase "sealant layer" as herein used refers only to outer layers, no matter how thin, it should also be recognized that in general, the outer 0.5 mil to 1.0 mil of a film is involved in the sealing of the film to itself or another layer. With respect to packages having only fin-type seals, as opposed to lap seals, the phrase "sealant layer" generally refers to the inside film layer of a package, as well as supporting layers adjacent this sealant layer often being sealed to itself, and frequently serving as a food contact layer in the packaging of foods.

25 As used herein, the phrase "tie layer" refers to any internal layer having the primary purpose of adhering two layers to one another.

30 As used herein, the phrase "skin layer" refers to an outermost layer of a multilayer film in packaging a product, this skin layer being subject to abuse.

As used herein, the term "lamination", and the phrase "laminated film", refer to the process, and resulting product, made by bonding together two or more layers of film or other materials. Lamination

can be accomplished by joining layers with adhesives, joining with heat and pressure, and even spread coating and extrusion coating. Multilayer films can be made via coextrusion and/or lamination.

As used herein, the term "extrusion" is used with reference to the process of forming continuous shapes by forcing a molten plastic material through a die, followed by cooling or chemical hardening.

5 Immediately prior to extrusion through the die, the relatively high-viscosity polymeric material is fed into a rotating screw of variable pitch, which forces it through the die.

As used herein, the term "coextrusion" refers to the process of extruding two or more materials through a single die with two or more orifices arranged so that the extrudates merge and weld together into a laminar structure before chilling, i.e., quenching. Coextrusion can be employed in film blowing, free  
10 film extrusion, and extrusion coating processes.

As used herein, the phrase "machine direction", herein abbreviated "MD", refers to a direction "along the length" of the film, i.e., in the direction of the film as the film is formed during extrusion and/or coating.

As used herein, the phrase "transverse direction", herein abbreviated "TD", refers to a direction  
15 across the film, perpendicular to the machine or longitudinal direction.

As used herein, "O<sub>2</sub>-transmission rate", also referred to as "OTR" and "oxygen permeability", is measured according to ASTM D 3985, a test known to those of skill in the film art.

As used herein, the "melt index" of a polymer is the amount, in grams, of a thermoplastic resin which can be forced through an orifice of 0.0825 inch diameter when subjected to a force of 2160 grams  
20 in ten minutes at a specified temperature, e.g., 190°C for many polymers. The test is performed by an extrusion rheometer described in ASTM D 1238.

Figure 1 illustrates a cross-sectional view of a preferred embodiment of multilayer film 10 of the present invention. The film comprises first layer 11 (an outer layer), second layer 12 (a core layer), and third layer 13 (also an outer layer). Preferably, the first and third layers 11 and 13 are designed to serve  
25 as sealing layers, i.e., comprise a polymer suitable for forming a seal via the application of heat or radiation, as is known to those of skill in the art.

In general, the film of the present invention comprises at least 3 layers. The two outer layers function as sealing layers, while the sole core layer, or at least one of a plurality of inner layers, provides the multilayer film with a desired tensile properties, while permitting a desired level of transmission of  
30 oxygen and carbon dioxide therethrough. Preferably, the film comprises from 3 to 15 layers, and more preferably, from 3 to 7 layers, and still more preferably, from 3 to 5 layers. Most preferably, the film comprises 3 layers, as illustrated in Figure 1, and most preferably, the outer layers, i.e., the first and third

layers, are of substantially identical chemical composition and are of substantially identical thickness. In general, the core layer should be at least as thick as each of the outer layers, and preferably the core layer is thicker than either of the outer layers.

5 In the multilayer film according to the present invention, the second layer is "chemically different" from the first layer and the third layer, in order that there be at least three discrete film layers. That is, if the second layer is chemically identical to either the first layer or the third layer, the resulting film becomes the equivalent of a film having less than three layers.

10 In general, the multilayer film of the present invention can have any total thickness which provides a desired rate of oxygen and carbon dioxide transmission, abuse resistance, tensile strength, etc. Preferably, the multilayer film of the present invention has a total thickness (i.e., a combined thickness of all layers), of from about 0.5 to 10 mils (1 mil equals 0.001 inch); more preferably, from about 1 to 5 mils; still more preferably, from 1 to 3 mils; yet still more preferably, from about 1 to 2.5 mils. Most preferably, the multilayer film has a thickness of from about 1.5 to 2 mils.

15 In general, in the multilayer film of the present invention, the two outer layers each make up from about 10 to 80 weight percent of the total weight of the multilayer film. Furthermore, the second, or core layer, can also make up from about 10 to 80 weight percent of the total weight of the film. Preferably, the two outer layers each make up from about 10 to 40 weight percent of the total weight of the multilayer film, and preferably the core layer makes up from about 20 to 80 weight percent of the total weight of the multilayer film.

20 With respect to preferred multilayer films according to the present invention, in general, the outer layers, i.e., sealing layers, each have a thickness of from about 0.05 to 4 mils. Preferably, each of the sealing layers has a thickness of from about 0.1 mil to 2 mils, and more preferably, from about 0.1 mil to 1.2 mils., still more preferably, from about 0.3 mil to 0.8 mil, and most preferably, each of the sealing layers has a thickness of about 0.4 to 0.5 mil.

25 With respect to preferred multilayer films according to the present invention, in general, the core layer (or layers) has a thickness of from about 0.1 mil to 8 mils, preferably, from about 0.2 mil to 4 mils, and more preferably, from about 0.2 mil to 2.4 mils, still more preferably, from about 0.5 mil to 1 mil, and most preferably, from 0.6 to 0.8 mil.

30 In general, the multilayer film of the present invention has an  $O_2$ -transmission rate of from about 500 to 50,000 cc/m<sup>2</sup>/ 24hr STP., preferably, from about 1,000 to 20,000 cc/m<sup>2</sup>/ 24hr STP., more preferably, from about 2,000 to 10,000 cc/m<sup>2</sup>/ 24hr STP., most preferably, from about 3,000 to 6,000 cc/m<sup>2</sup>/ 24hr STP.



In general, the outer layers of the multilayer film of the present invention comprise any homogeneous ethylene/alpha-olefin copolymer which permits the multilayer film to have an O<sub>2</sub>-transmission rate of from about 500 to 50,000 cc/m<sup>2</sup>/ 24hr STP. Although the outer film layers, i.e., the first and third layers in the preferred embodiment illustrated in Figure 1, can have the same or differing chemical composition, preferably the outer layers comprise substantially identical ethylene/alpha-olefin copolymer. Preferably, the ethylene/alpha-olefin copolymer in the outer layers has a density of less than or equal to about 0.915 g/cc, i.e., up to and including about 0.915 g/cc. Of course, the antifog agent, i.e., the surface active agent, is on the outer surface of an outer film layer which later becomes the inside layer of the package. If the package is printed, the printing is on the outer surface of the other outer film layer, which forms the outside layer of the package.

Homogeneous ethylene/alpha-olefin copolymers may be characterized by one or more methods known to those of skill in the art, such as molecular weight distribution ( $M_w/M_n$ ), composition distribution breadth index (CDBI), and narrow melting point range and single melt point behavior.

The molecular weight distribution ( $M_w/M_n$ ), also known as polydispersity, may be determined by gel permeation chromatography. The homogeneous ethylene/alpha-olefin copolymers useful in this invention will have a ( $M_w/M_n$ ) of less than 2.7. Preferably, the ( $M_w/M_n$ ) will have a range of about 1.9 to 2.5. More preferably, the ( $M_w/M_n$ ) will have a range of about 1.9 to 2.3.

The composition distribution breadth index (CDBI) of such homogeneous ethylene/alpha-olefin copolymers will generally be greater than about 70 percent. The CDBI is defined as the weight percent of the copolymer molecules having a comonomer content within 50 percent (i.e., plus or minus 50%) of the median total molar comonomer content. The CDBI of linear polyethylene, which does not contain a comonomer, is defined to be 100%.

The Composition Distribution Breadth Index (CDBI) is determined via the technique of Temperature Rising Elution Fractionation (TREF). CDBI determination clearly distinguishes the homogeneous copolymers used in the present invention (narrow composition distribution as assessed by CDBI values generally above 70%) from VLDPEs available commercially which generally have a broad composition distribution as assessed by CDBI values generally less than 55%. The benefits to the present invention accrue through the use of specific homogeneous ethylene/alpha-olefin copolymers having the above-described narrow composition distribution. The CDBI of a copolymer is readily calculated from data obtained from techniques known in the art, such as, for example, temperature rising elution fractionation as described, for example, in Wild et. al., J. Poly. Sci. Poly. Phys. Ed., Vol. 20, p.441 (1982).

Preferably, the homogeneous ethylene/alpha-olefin copolymers in the first and third layers have a CDBI greater than about 70%, i.e., a CDBI of from about 70% to 99%.

In general, the homogeneous ethylene/alpha-olefin copolymers in the multilayer films of the present invention also exhibit a relatively narrow melting point range, in comparison with "heterogeneous copolymers", i.e., polymers having a CDBI of less than 55%. Preferably, the homogeneous ethylene/alpha-olefin copolymers exhibit an essentially singular melting point characteristic, with a peak melting point ( $T_m$ ), as determined by Differential Scanning Colorimetry (DSC), of from about 60°C to 110°C. Preferably the homogeneous copolymer has a DSC peak  $T_m$  of from about 85°C to 105°C. As used herein, the phrase "essentially single melting point" means that at least about 80%, by weight, of the material corresponds to a single  $T_m$  peak at a temperature within the range of from about 60°C to 110°C, and essentially no substantial fraction of the material has a peak melting point in excess of about 115°C., as determined by DSC analysis.

DSC measurements are made on a Perkin Elmer System 7 Thermal Analysis System. Melting information reported are second melting data, i.e., the sample is heated at a programmed rate of 10°C./min. to a temperature below its critical range. The sample is then reheated (2nd melting) at a programmed rate of 10°C/min.

The presence of higher melting peaks is detrimental to film properties such as haze, and compromises the chances for meaningful reduction in the seal initiation temperature of the final film.

The homogeneous ethylene/alpha-olefin copolymer in the outer layers (i.e, the first and third homogeneous ethylene alpha-olefin copolymers) can, in general, be prepared by the copolymerization of ethylene and any one or more alpha-olefin. Preferably, the alpha-olefin is a  $C_3$ - $C_{20}$   $\alpha$ -monoolefin, more preferably, a  $C_4$ - $C_{12}$   $\alpha$ -monoolefin, still more preferably, a  $C_4$ - $C_8$   $\alpha$ -monoolefin. Still more preferably, the alpha-olefin comprises at least one member selected from the group consisting of butene-1, hexene-1, and octene-1, i.e., 1-butene, 1-hexene, and 1-octene, respectively. Most preferably, the alpha-olefin comprises octene-1, and/or a blend of hexene-1 and butene-1.

In general, the ethylene/alpha-olefin copolymer comprises a copolymer resulting from the copolymerization of from about 80 to 99 weight percent ethylene and from 1 to 20 weight percent alpha-olefin. Preferably, the ethylene/alpha-olefin copolymer comprises a copolymer resulting from the copolymerization of from about 85 to 95 weight percent ethylene and from 5 to 15 weight percent alpha-olefin.

In general, the outer layers can consist essentially of homogeneous ethylene/alpha-olefin copolymer (or copolymers), or can have still additional polymers blended therewith. However, in each of

the outer layers, the homogeneous ethylene/alpha-olefin is preferably present in an amount of at least about 50 weight percent, based on the weight of the respective outer layer. More preferably, the homogeneous ethylene/alpha-olefin is present in an amount of at least about 75 weight percent, based on the weight of the respective outer layer. Most preferably, the homogeneous ethylene/alpha-olefin is present in an amount of about 100 weight percent, based on the weight of the respective outer layer. If another polymer, i.e., a "secondary polymer", is present in admixture with the homogeneous ethylene/alpha-olefin copolymer, preferably this secondary polymer comprises at least one member selected from the group consisting of polyethylene, ethylene vinyl acetate, ethylene methyl acrylate, ethylene butyl acrylate, ethylene methyl acrylic acid, ionomer, and ethylene/alpha-olefin.

Preferably, the first film layer is directly adhered to a first side of the second film layer, and the third film layer is directly adhered to a second side of the second film layer.

The homogeneous ethylene/alpha-olefin copolymers can be prepared through the use of a metallocene catalyst, and/or any additional single site catalyst. Furthermore, the homogeneous ethylene/alpha-olefin copolymers can be prepared in accordance with any suitable polymerization process, including slurry polymerization, gas phase polymerization, and high pressure polymerization processes. U.S. Patent No. 5,206,075, U.S. Patent No. 5,241,031, and PCT International Application WO 93/03093, each of which is hereby incorporated by reference thereto, in its entirety, disclose homogeneous polymers and methods for making same.

Slurry polymerization processes generally use superatmospheric pressures and temperatures in the range of 40°-100°C. In a slurry polymerization, a suspension of solid, particulate polymer is formed in a liquid polymerization medium to which ethylene and comonomers and often hydrogen along with catalyst are added. The liquid employed in the polymerization medium can be an alkane, cycloalkane, or an aromatic hydrocarbon such as toluene, ethylbenzene or xylene. The medium employed should be liquid under the conditions of polymerization, and relatively inert. Preferably, hexane or toluene is employed.

Alternatively, the homogeneous ethylene/alpha-olefin copolymer is prepared by gas-phase polymerization. A gas-phase polymerization process utilizes super-atmospheric pressure and temperature in the range of about 50°-120°C. Gas phase polymerization can be performed in a stirred or fluidized bed of catalyst and product particles in a pressure vessel adapted to permit the separation of product particles from unreacted gases. Ethylene, comonomer, hydrogen and an inert diluent gas such as nitrogen can be introduced or recirculated so as to maintain the particles at temperatures of 50°-120°C. Triethylaluminum may be added as needed as a scavenger of water, oxygen, and other

impurities. Polymer product can be withdrawn continuously or semicontinuously, at a rate such as to maintain a constant product inventory in the reactor. After polymerization and deactivation of the catalyst, the product polymer can be recovered by any suitable means. In commercial practice, the polymer product can be recovered directly from the gas phase reactor, freed of residual monomer with a nitrogen purge, and used without further deactivation or catalyst removal.

The homogeneous ethylene/alpha-olefin copolymer can also be produced by a high pressure process, in the presence of a catalyst system comprising a cyclopentadienyl-transition metal compound and an alumoxane compound. It is important, in the high-pressure process, that the polymerization temperature be above about 120°C., but below the decomposition temperature of the polymer product. It is also important that the polymerization pressure be above about 500 bar (kg/cm<sup>2</sup>). In those situations wherein the molecular weight of the polymer product that would be produced at a given set of operating conditions is higher than desired, any of the techniques known in the art for control of molecular weight, such as the use of hydrogen or reactor temperature, may be used in the process of this invention.

Further details regarding the production and use of one genus of homogeneous ethylene/alpha-olefin copolymers are disclosed in U.S. Patent No. 5,206,075, to HODGSON, Jr.; U.S. Patent No. 5,241,031, to MEHTA; PCT International Publication Number WO 93/03093, in the name of Exxon Chemical Company; PCT International Publication Number WO 90/03414, in the name of Exxon Chemical Patents, Inc., all four of which are hereby incorporated in their entireties, by reference there. Still another genus of homogeneous ethylene/alpha-olefin copolymers is disclosed in U.S. Patent No. 5,272,236, to LAI, et. al., and U.S. Patent No. 5,278,272, to LAI, et. al., both of which are hereby incorporated in their entireties, by reference thereto.

In general, although the multilayer film of the present invention can have a plurality of inner layers, including a plurality of tie layers as well as a plurality of core layers, most preferably the multilayer film of the present invention has no tie layers, and only one core layer as the sole inner layer of the film.

In general, core layer 12 comprises a polyolefin. Preferably, the core layer comprises at least one member selected from the group consisting of polyethylene homopolymer, polypropylene homopolymer, ethylene/alpha-olefin copolymer, propylene/ethylene copolymer, and ethylene/unsaturated ester copolymer, styrene homopolymer, and styrene copolymer. More preferably, the core layer comprises at least one member selected from the group consisting of propylene homopolymer and propylene/ethylene copolymer containing from 0.1 to 6 weight percent ethylene, and styrene/butadiene copolymer. Still more preferably, the core layer comprises a propylene/ethylene copolymer containing from about 0.1 to 6 weight percent ethylene wherein the propylene/ethylene

copolymer is present in an amount of from about 50 to 100 weight percent, based on the weight of the core layer. Most preferably the core layer comprises a propylene/ethylene copolymer containing from about 2 to 5 weight percent ethylene, present in an amount of about 100 weight percent, based on the weight of the core layer.

5 Preferably, the polyolefin, or a preferred polyolefin, is present in the core layer in an amount of at least about 50 weight percent, based on the weight of the core layer, and more preferably, in an amount of at least about 75 weight percent, based on the weight of the core layer. Most preferably, a preferred polyolefin is present in an amount of about 100 weight percent, based on the weight of core layer.

10 As with the homogeneous ethylene/alpha-olefin copolymer polymer of the outer layers of the multilayer film of the present invention, the polymer or polymers in the inner layer, including both core layers as well as tie layers, can be produced in accordance with any suitable polymerization process, including slurry polymerization, gas phase polymerization, and high pressure polymerization processes, as discussed in above, in detail. Furthermore, the core and tie layer or layers can also be prepared through the use of a metallocene catalyst, and/or any additional single site catalyst, also as discussed  
15 above.

Regardless of whether the core layer comprises a single-site-catalyzed copolymer, the chemical composition of the second layer is different from the chemical composition of the first layer and the third layer. Preferably, the core layer has a greater heat resistance than the outer layers, and preferably, the core layer provides the majority of the mechanical strength (e.g., modulus, tensile strength, impact  
20 strength, etc.) of the multilayer film.

Figure 2 illustrates a cross-sectional view of multilayer film 14 according to the present invention, which is an alternative of the preferred multilayer film illustrated in Figure 1. In Figure 2, multilayer film 14 is comprised of five layers, including first layer 15, second layer 16, third layer 17, fourth layer 18, and fifth layer 19. First layer 15, and fifth layer 19, which are outer layers, are preferably also sealing layers.  
25 Second layer 16 and fourth layer 18 are preferably tie layers. Third layer 19, a core layer, preferably functions to provide the multilayer film with desired physical properties, such as tensile strength, heat resistance, etc. Of course, the antifog agent, i.e., the surface active agent, is on the outer surface of an outer film layer which later becomes the inside layer of the package. If the package is printed, the printing is on the outer surface of the other outer film layer, which forms the outside layer of the package.

30 In general, tie layers 16 and 18 need be only thick enough to effectuate the desired tying function. Preferably, the tie layer or layers each has a thickness of from about 0.001 to 0.5 mil., more preferably from about 0.01 to 0.4 mil., and most preferably from about 0.1 to 0.3 mil.

Although most preferably the multilayer film of the present invention does not comprise a tie layer, in general, the multilayer film of the present invention can comprise one or more tie layers. In general, the tie layer or layers may comprise any polymer which adheres to both the layers which the tie layer is tying together.

5 The composition, number, and thickness of the tie layer or layers are as known to those of skill in the art of films.

The polymer components used to fabricate multilayer films according to the present invention may also contain appropriate amounts of other additives normally included in such compositions. These include slip agents such as talc, antioxidants, fillers, dyes, pigments and dyes, radiation stabilizers, antistatic agents, elastomers, and the like additives known to those of skill in the art of packaging films.

10 Multilayer films in accordance with the present invention can be manufactured using film fabrication technologies well-known in the art. For example, the base film may be extruded into a film using a flat die, or extruded into a film using an annular die, and the heat seal layer formed thereon by solvent deposition, lamination or coextrusion techniques. However, the preferred method of manufacture of the multilayer film of the present invention is via simultaneous coextrusion, in an annular die, of all the layers of the multilayer film, including the outer (sealing) layers, the core layer, and optionally, the one or more tie layers.

Figure 3 illustrates a schematic view of a process according to the present invention, for producing a multilayer film 10 in accordance with the present invention. Although for the sake of simplicity only one extruder 20 is illustrated in Figure 3, there are preferably at least 2 extruders, and more preferably, at least three extruders. That is, preferably at least one extruder, and more preferably two extruders, supply molten polymer to coextrusion die 21 for the formation of, for example, outer layers 11 and 13 as illustrated in Figure 1, and at least one additional extruder supplied molten polymer to coextrusion die 21 for the formation of, for example, core layer 12 as illustrated in Figure 1. Each of the extruders is supplied with polymer pellets suitable for the formation of the respective layer it is extruding. The extruders subject the polymer pellets to sufficient pressure and heat to melt the polymer and thereby prepare it for extrusion through a die.

25 Taking extruder 20 as an example, each of the extruders is preferably equipped with a screen pack 22, a breaker plate 23, and a plurality of heaters 24. Each of the coextruded film layers is extruded between mandrel 25 and die 21, and the extrudate is cooled by cool air flowing from air ring 26. The resulting blown bubble is thereafter guided into a collapsed configuration by nip rolls 29, via guide rolls 28. The collapsed tube is optionally passed over treator bar 30, and is thereafter passed over idler rolls

31, and around dancer roll 32 which imparts tension control to collapsed tube 33, after which the collapsed tube is wound into roll 34 via winding mechanism 35.

The process according to the present invention can, in general, be carried out the manner illustrated in Figure 3. Preferably the process is carried out in a manner to result in the preferred multilayer film according to the present invention as described above. In order to extrude a first composition comprising the first ethylene/alpha-olefin copolymer to form the first layer, and extrude a second composition comprising the polyolefin to form the second layer, and extrude a third composition comprising the second ethylene/alpha-olefin of the third layer, it is necessary to carry out the process by selecting and proportioning each of these three chemical compositions in an manner to result in a multilayer film having a second layer between the first and third layers, and to provide the multilayer film with an  $O_2$ -transmission rate of from about 500 to 50,000 cc/m<sup>2</sup>/ 24hr STP. The details of selecting and proportioning are readily evident to those of skill in the art in view of the above detailed description of the multilayer film of the present invention. Preferably, the process is carried out to result in a preferred film according to the present invention.

Although the multilayer film of the present invention is preferably not irradiated, optionally the film may be irradiated. In the irradiation process, the film is subjected the film to an energetic radiation treatment, such as corona discharge, plasma, flame, ultraviolet, X-ray, gamma ray, beta ray, and high energy electron treatment, which induce cross-linking between molecules of the irradiated material.

Radiation dosages are referred to herein in terms of the radiation unit "RAD", with one million RADS, also known as a megarad, being designated as "MR". A suitable radiation dosage of high energy electrons is in the range of up to about 12 MR, more preferably about 2 to about 9 MR, and still more preferably, about 3 MR. Preferably, irradiation is carried out by an electron accelerator and the dosage level is determined by standard dosimetry methods.

Figure 4 illustrates a vertical form fill and seal apparatus to be used in packaging process according to the present invention. Vertical form fill and seal equipment is well known to those of skill in the packaging arts. The following documents disclose a variety of equipment suitable for vertical form fill and seal: U.S. Patent No. 2,956,383; U.S. Patent No. 3,340,129 to J.J. GREVICH; U.S. Patent No. 3,611,657, to KIYOSHI INOUE, et. al.; U.S. Patent No. 3,703,396, to INOUE, et. al.; U.S. Patent No. 4,103,473, to BAST, et. al.; U.S. Patent No. 4,506,494, to SHIMOYAMA, et. al.; U.S. Patent No. 4,589,247, to ; U.S. Patent No. 4,532,752, to TAYLOR; U.S. Patent No. 4,532,753, to KOVACS; U.S. Patent No. 4,571,926, to SCULLY; and Great Britain Patent Specification No. 1 334 616, to de GROOT, et. al., each of which is hereby incorporated in its entirety, by reference thereto.

In Figure 4, a vertical form fill and seal apparatus 40 is schematically illustrated. Apparatus 40 utilizes multilayer film 41 according to the present invention. Product 42, to be packaged, is supplied to apparatus 40 from a source (not illustrated), from which a predetermined quantity of product 42 reaches upper end portion of forming tube 44 via funnel 43, or other conventional means. The packages are formed in a lower portion of apparatus 40, and flexible sheet material 41 from which the bags or packages are formed is fed from roll 51 over certain forming bars (not illustrated), is wrapped about forming tube 44, and is provided with longitudinal seal 47 by longitudinal heat sealing device 46, resulting in the formation of vertically-oriented tube 48. End seal bars 45 operate to close and seal horizontally across the lower end of vertically-sealed tube 48, to form pouch 50 which is thereafter immediately packed with product 42. Film drive belts 52, powered and directed by rollers, as illustrated, advance tube 48 and pouch 50 a predetermined distance, after which end seal bars 45 close and simultaneously seal horizontally across the lower end of vertically-sealed tube 48 as well as simultaneously sealing horizontally across upper end of sealed pouch 49, to form a product packaged in sealed pouch 49. The next pouch 50, thereabove, is then filled with a metered quantity of product 42, forwarded, and so on. It is also conventional to incorporate with the end seal bars a cut-off knife (not shown) which operates to sever a lower sealed pouch 49 from the bottom of upstream pouch 50.

In carrying out the packaging process of the present invention, preferably the vertical form fill and seal machine forms, fills, and seals at least 15 packages per minute, preferably from about 15 to 45 packages per minute, without substantial burn through of the film at the seals.

Although the packaging process may be carried out with any film according to the present invention, the packaging process is preferably carried out using a preferred film according to the present invention. Preferably, the film is sealed at the lowest possible temperature at which relatively strong seals are produced. In general, the film is sealed at a temperature of from about 70°C to 150°C.; more preferably, from about 80°C to 140°C, and still more preferably, from about 90°C to 130°C.

As is apparent from the data for the hot tack strength of the multilayer film of the present invention as provided for Examples 1-3 in Table I below, surprisingly it has been discovered that preferred multilayer films of the present invention exhibit a hot tack strength of from about 4 to 15 Newtons. More particularly, in contrast to hot tack strength of only 1.6 and 2.7 Newtons for Example 4 (comparative) and Example 5 (comparative), the hot tack strength for Examples 1-3 is 10.9 Newtons, 6.8 Newtons, and 8.8 Newtons, respectively.

In general, the packaging process is carried out with the packaging of an oxygen-sensitive product. Preferably, the oxygen-sensitive product comprises at least one cut vegetable selected from



the group consisting of lettuce, cabbage, broccoli, green beans, cauliflower, spinach, kale, carrot, onion, radish, endive, and escarole; more preferably, at least one member selected from the group consisting of lettuce, cabbage, green beans, kale, carrot, onion, radish, endive, and escarole, where the film has an oxygen permeability of from about 2000 to 10,000 cc/m<sup>2</sup>/ 24hr STP.

5           Figure 5 illustrates one embodiment of a packaged product 49 of the present invention, the product being packaged in sealed pouch 56 having vertical seal 47 and end seals 57. Package 56 is a multilayer film of the present invention as produced in a vertical form fill and seal apparatus, in accordance with the packaging process of the present invention as described above. Of course, the antifog agent, i.e., the surface active agent, is on the outer surface of an outer film layer which serves as  
10           the inside layer of the package. If the package is printed, the printing is on the outer surface of the other outer film layer, which forms the outside layer of the package.

          In general, the product in the package can be any oxygen-sensitive product, as described above. Preferably, the oxygen-sensitive product comprises at least one cut vegetable selected from the group consisting of lettuce, cabbage, broccoli, green beans, cauliflower, spinach, kale, carrot, onion,  
15           radish, endive, and escarole; more preferably, at least one member selected from the group consisting of lettuce, cabbage, green beans, kale, carrot, onion, radish, endive, and escarole, where the film has an oxygen permeability of from about 2000 to 10,000 cc/mil/m<sup>2</sup>/ 24hr STP., and, still more preferably, an oxygen permeability of from about 3000 to 6000 cc/m<sup>2</sup>/ 24hr STP.

          The invention is illustrated by the following examples, which are provided for the purpose of  
20           representation, and are not to be construed as limiting the scope of the invention. Unless stated otherwise, all percentages, parts, etc. are by weight.

#### EXAMPLE 1 - 9

          A series of coextruded, multilayer films were produced on conventional hot blown film  
25           equipment equipped with a multilayer annular die, to produce films having an A/B/C-type structure. The films had average thicknesses of from 1.3 to 1.8 mils. For each film, the two outer layers A and C, each of which serves as a sealing layer, were each composed of either (a) a metallocene-catalyzed ethylene/octene copolymer ("MCPE#1") having a density of about 0.902 gm/cc, and a melt index of about 1.0 gm/10 min (using Condition E of ASTM D-1238), or (b) a metallocene-catalyzed  
30           ethylene/octene copolymer ("MCPE#2") having a density of about 0.908 gm/cc, and a melt index of about 1.0 gm/10 min (using Condition E of ASTM D-1238), with each having average thickness of from 0.4 mils to 0.8 mils per layer, i.e., each making up from 22% to 44% of the total thickness of the multilayer

film. For each of the outer film layers, the metallocene-catalyzed polyethylene was preblended with FSU93E (TM) slip/antiblock concentrate, obtained from A. Schulman of Akron, Ohio, to allow easy separation of the film plys at the winder, and for good machinability on the VFFS packaging equipment. Furthermore, for layer C, which served as the food contact layer, the blend further included about 20 weight percent of ATMER 8174 (TM) antifog masterbatch containing 20% active surface agent based in a LDPE having a melt index of 4.0 gm/10 min (Condition E of ASTM D-1238).

The B-layer, i.e., the only inner layer, contained propylene/ethylene copolymer ("PEC"). The propylene/ethylene copolymer in the B-layer contained about 3.3 weight percent ethylene, and had a density of about 0.895 g/cc and a melt flow rate of about 3.8 g/10 min. (Condition L of ASTM D-1238).

The polymer formulations for the A-layer, B-layer, and C layer were then fed into the hoppers of extruders which fed the coextrusion die. The materials were coextruded through an annular coextrusion die, exited the die, and were blown to a desired width while simultaneously being cooled with an air ring. The cooled film was then collapsed, ply separated, and wound on cores for further processing. Examples 7 and Example 8 were subsequently printed without being corona treated at extrusion, being corona treated only at the printing press. Additionally, the outer surface of layer C of Examples 8 and 9 were also corona treated to a surface tension level of from 42 to 46 dynes at extrusion and subsequently printed.

For Examples 1-9, Table I, below, provides the structure, total thickness and layer thicknesses, and amount of antifog masterbatch in Layer C; Table II provides the antifog rating; and Table III provides the modulus, gloss, and  $O_2$ -transmission rate for Examples 7-11. The films of Examples 1-9 performed well as rollstock for VFFS equipment. The films also performed well in the packaging of oxygen-sensitive products, such as lettuce.

#### Example 10 (Comparative)

A coextruded, multilayer film was produced on conventional hot blown film equipment equipped with a multilayer annular die, to produce film having an A/B/A-type structure. The film had an average thickness of 1.8 mils. The outer layers A, each of which serves as a sealing layer, were each composed of a metallocene-catalyzed ethylene/octene copolymer (MCPE1) having a density of about 0.902 gm/cc, and a melt index of about 1.0 gm/10 min (using Condition E of ASTM D-1238), having an average thickness of about 0.5 mils per layer, i.e., each making up about 28% of the total thickness of the multilayer film. For each of the outer film layers, the metallocene-catalyzed polyethylene was preblended

with FSU93E (TM) slip/antiblock concentrate, obtained from A. Schulman of Akron, Ohio, to allow easy separation of the film plys at the winder, and for good machinability on the VFFS packaging equipment.

The B-layer, i.e., the core layer, contained propylene/ethylene copolymer. The propylene/ethylene copolymer in the B-layer contained about 3.3 weight percent ethylene, and had a  
5 density of 0.895 g/cc and a melt flow rate of 3.8 g/10 min. (Condition L of ASTM D-1238).

The polymer formulations for the A-layers and B-layer were then fed into the hoppers of extruders which feed the coextrusion die. The materials were coextruded through an annular coextrusion die, exited the die, and were blown to a desired width while simultaneously being cooled with  
10 an air ring. The cooled film was then collapsed, ply separated, and wound on cores for further processing. The films were especially suitable for use as rollstock for VFFS equipment. The films were also especially suitable for the packaging of oxygen-sensitive products, such as lettuce.

#### EXAMPLE 11 (Comparative)

A coextruded, multilayer films was produced on conventional hot blown film equipment  
15 equipped with a multilayer annular die, to produce films having an A/B/C/A-type structure. The film had average thickness of 1.8 mils. For each film, layers A and C were each composed of a metallocene-catalyzed ethylene/octene copolymer one (MCPE2) having a density of about 0.908 gm/cc, and a melt index of about 1.0 gm/10 min (using Condition E of ASTM D-1238), with each having average thickness  
20 of from 0.2 mils to 0.5 mils per layer, i.e., each making up from 11% to 28% of the total thickness of the multilayer film. For each of the film layers A and C, the metallocene-catalyzed polyethylene was preblended with FSU93E (TM) slip/antiblock concentrate, obtained from A. Schulman of Akron, Ohio, to allow easy separation of the film plys at the winder, and for good machinability on the VFFS packaging equipment. Furthermore, for layer C, the blend further included about 20 weight percent ATMER 8174 (TM) antifog masterbatch containing 20% active surface agent based in a LDPE having a melt index of  
25 4.0 gm/10 min (Condition E of ASTM D-1238).

The B-layer, i.e., the core layer, contained propylene/ethylene copolymer. The propylene/ethylene copolymer in the B-layer contained about 3.3 weight percent ethylene, and had a density of 0.895 g/cc and a melt flow rate of 3.8 g/10 min. (Condition L of ASTM D-1238).

The polymer formulations for the A-layers, B-layer, and C layer were then fed into the hoppers of  
30 extruders which feed the coextrusion die. The materials were coextruded through an annular coextrusion die, exited the die, and were blown to a desired width while simultaneously being cooled with an air ring. The cooled film was then collapsed, ply separated, and wound on cores for further

processing. Layer A adjacent to layer C was electrostatically treated, corona treated, to a surface tension level of 42 to 46 dynes at extrusion and subsequently printed. The films were especially suitable for use as rollstock for VFFS equipment. The films were also especially suitable for the packaging of oxygen-sensitive products, such as lettuce.

5

TABLE I

Film of Example No.	Film Layer Composition & Structure	Film Layer Thickness (mils)	Antifog Masterbatch* (weight percent)
1	MCPE#1/PEC/MCPE#1	.5/.8/.5	10
2	MCPE#1/PEC/MCPE#1	.5/.8/.5	6
3	MCPE#1/PEC/MCPE#1	.4/.5/.4	6
4	MCPE#1/PEC/MCPE#1	.4/.5/.4	10
5	MCPE#1/PEC/MCPE#1	.5/.8/.5	15
6	MCPE#1/PEC/MCPE#1	.5/.8/.5	20
7	MCPE#2/PEC/MCPE#2	.5/.8/.5	20
8	MCPE#2/PEC/MCPE#2	.5/.8/.5	10
9	MCPE#2/PEC/MCPE#2	.5/.8/.5	5
10	MCPE#1/PEC/MCPE#1	.5/.8/.5	0
11	MCPE#2/PEC/MCPE#2/MCPE#2	.5/.8/.3/.2	20

\* Weight percent antifog masterbatch in Layer C.

Antifog was measured using the "Water Beaker Test", which is visual rating test in which 200 ml of water are placed in 250 ml beaker and covered with a sample of test film and placed in a temperature controlled cabinet at approximately 4°C. The ratings are as follows:

- 1 : opaque layer of small fog droplets;
- 2 : opaque (or transparent) layer of large droplets;
- 3 : complete layer of large transparent droplets;
- 4 : randomly scattered or only large transparent droplet(s); and
- 5 : transparent film having no visible water.

15

Of course, the ratings are best at a rating of "5", and worst at a rating of "1". The Water Beaker test has been found to be a rather harsh test, as film performance in the packaging of vegetables, such as cut

lettuce, is rarely, if ever, as low as determined using the Water Beaker Test. For example, the film of Example 8 scored about a 4 after one day using this same rating scale when used to package chopped lettuce (vs. 3 in the Water Beaker Test, as shown in Table II below), and when used to package chopped lettuce, the films of Examples 9 and 11 scored a 3 and a 2, respectively.

5

TABLE II

WATER BEAKER TEST RESULTS FOR FILMS OF EXAMPLES 1-11

Film of Example No.	Fog Rating at 2-3 hours	Fog Rating at 24 hours
1	2.5	3
2	2.5	3
3	2.5	3
4	2.5	3
5	2	2.5
6	2.5	3
7	3.5	4
8	3	3
9	2	3
10	1	1
11	1	1

10

TABLE III

Film of Example No.	Modulus (psi)	Haze (percent)	Gloss (at 45 degrees)	O <sub>2</sub> Transmission Rate (cc/m <sup>2</sup> 24hr.STP)
7	60,000	7.7	68	4,600
8	57,300	7.8	68	4,600
9	60,600	8.6	67	4,300
10	53,900	6.2	69	4,600

11	66,700	7.6	70	4,500

Ink adhesion was measured, and is commonly measured, by a cellophane tape adhesion test (the "Standard Tape Test"). This test provides a qualitative determination of the ink-to-substrate bond strength, relative to the strength of the bond of the adhesive on the tape to the surface of the ink.

5 The Standard Tape Test is carried out using a one-inch wide, 3M No. 610 High Tack cellophane tape. A 6-inch-long, 1-inch wide strip of pressure-sensitive tape is applied over a printed surface of the film, with the tape strip being smoothed down onto the printed film surface. If possible, the tape should cover a single lay and multiple lays of ink. The tape is grasped firmly between the thumb and forefinger of one hand while holding the sheet down firmly on a smooth, flat surface with the other. The tape is then  
10 pulled back at a little less than a 180-degree angle at relatively low speed.

When the films of Examples 8, 9, 10, and 11 were corona treated in-line at extrusion to a level of 42 to 46 dynes, 100% print adhesion (i.e., ink adhesion) was achieved for each variant, using the Standard Tape Test. Comparatively, when the films of Examples 7 and 8 were not in-line treated at extrusion and only treated at the press, only 50% adhesion was achieved using the Standard Tape Test,  
15 and the highest surface treatment level achievable was 35 dynes for the film of Example 7 and 80% adhesion was achieved with a treatment level of 37 dynes for the film of Example 8, again using the Standard Tape Test.

#### EXAMPLES 12 - 14

20 A series of coextruded, multilayer films are produced on conventional hot blown film equipment equipped with a multilayer annular die, to produce films having an A/B/C-type structure. The films have average total thicknesses of from 1.5 to 2.0 mils. For each film, the two sealing layers A and C, contained a metallocene-catalyzed ethylene/octene copolymer having a density of 0.902 gm/cc, and a melt index of 1.0 gm/10 min (using Condition E of ASTM D-1238), with average thickness of about 0.5  
25 mils per layer, i.e., approximately 28% of the total thickness of the multilayer film. The metallocene-catalyzed polyethylene was preblended with a slip/antiblock concentrate, known as FSU93E, obtained from A. Schulman of Akron, Ohio, to allow easy separation of the film plys at the winder, and for good machinability on the VFFS packaging equipment.

The B-layer, i.e., the core layer, consisted of propylene/ethylene copolymer in Examples 12 and  
30 13, propylene homopolymer in Example 14, and styrene/butadiene copolymer in Example 15. The

propylene/ethylene copolymer (EPC) in the B-layer contains about 3.3 weight percent ethylene, and has a density of about 0.895 g/cc and a melt flow rate of 3.8 g/10 min. (Condition L of ASTM D-1238). The propylene homopolymer (PP) in the B-layer has a density of about 0.90 g/cc and a melt flow rate of about 3.6 g/10 min (Condition L of ASTM D-1238). The styrene/butadiene copolymer (SBC) contains about 25 percent butadiene, and has a density of about 1.01 g/cc and a melt flow rate of about 8.0 g/10 min (Condition G of ASTM D-1238). The core layer of each variant is about 0.8 mil, i.e. approximately 44% of the total thickness of the multilayer film.

The polymer formulations for the A-layer, B-layer and C-layer are then fed into the hoppers of extruders which feed the coextrusion die. The materials are coextruded through an annular coextrusion die, exited the die, and are blown to a desired width while simultaneously are being cooled with an air ring. The cooled film is then collapsed, ply separated, and is then wound on cores for further processing. The films are especially suitable for use as rollstock for VFFS equipment. The films are also especially suitable for the packaging of oxygen-sensitive products.

Layer C of the films of Examples 12 and 13 contained a surface-active agent (Polybatch<sup>®</sup> AF1085 antifog masterbatch containing 10% glycerol mono-oleate ester based in a LDPE having a melt index of 2.0 gm/10 min Condition E of ASTM D-1238) which served as an antifog agent. While Layer C of the film of Example 12 contained the antifog concentrate in an amount of about 20 weight percent, Layer C of the film of Example 13 contained the antifog concentrate in an amount of about 15 weight percent. It is believed that for both the films of Examples 12 and 13, these levels of antifog agent in Layer C would result in a film which exhibits a antifog rating of about 3, after 1 day using the water beaker test described above. Of course, Layer C of the films of Examples 14 and 15 could also be preblended with an antifog masterbatch in the manner set forth for the films of Examples 1-11 above, and similar results can thereby be achieved.

TABLE IV

	Films of Examples 12 and 13	Film of Example 14	Film of Example 15
Structure	A/B/C	A/B/C	A/B/C
MCPE in Layers A and C	MCPE1	MCPE1	MCPE1
Where B=	EPC	PP	SBC
Gauge (mils)	.5/.8/.5	.5/.8/.5	.5/.8/.5

Modulus (psi)	54,000	97,000	87,000
OTR (cc/m <sup>2</sup> /24hr.STP)	4,600	3,600	7,200
CO <sub>2</sub> TR (cc/m <sup>2</sup> /24hr.STP)	17,000	10,000	25,000
Haze (%)	6.2	7.2	60
Gloss (45 deg.)	69	73	74

Table V

Component Identity	Commercial Name	Density g/cc	Melt Index (g/10min)	Supplier
MCPE#1	AFFINITY PL 1880 (TM)	0.902	1.0 (ASTM D-1238 condition E)	The Dow Chemical Co., 2040 Dow Center, Midland, MI 48674
MCPE #2	AFFINITY PL 1840 (TM)	0.908	1.0 (ASTM D-1238 condition E)	The Dow Chemical Co.
EPC	ESCORENE® PD 9302	0.895	3.8 (ASTM D-1238 condition L)	Exxon Chemical Co. P.O. Box 3272 Houston, TX 77253-3272
PP	ESCORENE® PD 4062	0.90	3.6 (ASTM D-1238 condition L)	Exxon Chemical Co.
SBC	K-Resin® KK36	1.01	8.0 (ASTM D-1238 condition G)	Phillips 66 Co. P.O. Box 58966 Houston, TX 77258-8966
AFMB#1	ATMER® 8174	(no data)	(no data)	ICI Specialty Chemicals, Cherry Lane, PO Box 231, New Castle DE 19720
AFMB#2	POLYBATCH® AF-1085	0.92-0.925	18 (ASTM D-1238 condition E)	A. Schulman, Inc. 3550 West Market St., Akron, Ohio 44313
S/ABMB	POLYBATCH® FSU-93-E	1.10	11 (ASTM D-1238 Condition E)	A. Schulman, Inc.



Although the present invention has been described with reference to particular means, materials, and embodiments, it should be noted that the invention is not to be limited to the particulars disclosed, and extends to all equivalents within the scope of the claims.

## WHAT IS CLAIMED IS:

## 1. A multilayer film, comprising:

## (A) a first outer layer comprising:

- 5 (i) a polymeric component comprising at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer; and
- (ii) a surface-active agent component comprising at least one member selected from the group consisting of ester of aliphatic alcohol, polyether, polyhydric alcohol, ester of polyhydric
- 10 aliphatic alcohol, and polyethoxylated aromatic alcohol,

## (B) at least one inner layer comprising polyolefin; and

## (C) a second outer layer comprising at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer;

- 15 wherein the surface-active component is present over the entire outside surface of the first outer layer, the inner layer is between the first outer layer and the second outer layer, the inner layer is chemically different from the first outer layer and the second outer layer, and the multilayer film has an  $O_2$ -transmission rate of from about 500 to 50,000 cc/m<sup>2</sup> 24hr STP.

- 20 2. The multilayer film according to claim 1, further comprising printing on an outer surface of the second outer layer, wherein the second outer layer has an outer surface having a surface tension of greater than 38 dynes, the outer surface of the second outer layer being substantially free of a surface-active agent, and the printing being adhered to the film to a level of at least about 80 percent as measured by a standard tape test.

25

3. The multilayer film according to claim 1, having an  $O_2$ -transmission rate of from about 1000 to 20,000 cc/m<sup>2</sup> 24hr STP.

30

4. The multilayer film according to claim 1, wherein at least one inner layer has a modulus higher than the first outer layer modulus.



5. The multilayer film according to claim 4, wherein at least one inner layer has a modulus higher than the second outer layer modulus.

6. The multilayer film according to claim 1, wherein:

5           the first outer layer comprises homogeneous ethylene/alpha-olefin copolymer; and  
          the surface-active agent comprises at least one member selected from the group consisting of  
polyoxyethylene (20) sorbitan monostearate, polyoxyethylene (20) sorbitan monolaurate,  
polyoxyethylene (20) monopalmitate, polyoxyethylene (20) sorbitan tristearate, polyoxyethylene (20)  
sorbitan trioleate, poly(oxypropylene), polyethoxylated fatty alcohol, and polyoxyethylated 4-nonylphenol,  
10 polyhydric alcohol, propylene diol, propylene triol, and ethylene diol.

7. The multilayer film according to claim 6, wherein the first outer layer comprises a first homogeneous  
ethylene/alpha-olefin copolymer, and the second outer layer comprises a second homogeneous  
ethylene/alpha-olefin copolymer.

15

8. The multilayer film according to claim 7, wherein the first homogeneous ethylene/alpha-olefin  
copolymer has a density of less than about 0.915 grams per cubic centimeter, and the second  
homogeneous ethylene/alpha-olefin copolymer has a density of less than about 0.915 grams per cubic  
centimeter.

20

9. The multilayer film according to claim 7, wherein the first homogeneous ethylene/alpha-olefin  
copolymer has a melting point of up to 110°C, and the second homogeneous ethylene/alpha-olefin  
copolymer has a melting point of up to 110°C.

25

10. The multilayer film according to claim 9, wherein at least one inner layer comprises at least one  
member selected from the group consisting of ethylene homopolymer, propylene homopolymer,  
ethylene/alpha-olefin copolymer, propylene/ethylene copolymer, ethylene/unsaturated ester copolymer,  
styrene homopolymer, styrene copolymer, and ethylene cycloolefin copolymer.

30

11. The multilayer film according to claim 10, wherein:

          the first homogeneous ethylene alpha-olefin copolymer comprises a copolymer resulting from  
the copolymerization of from about 99 to 80 weight percent ethylene, based on total monomer weight,

34

and from about 1 to 20 weight percent of a first alpha-olefin, based on total monomer weight, wherein the first alpha-olefin comprises at least one member selected from the group consisting of butene, hexene, and octene;

5 the second layer comprises at least one member selected from the group consisting of polypropylene homopolymer, and propylene/ethylene copolymer containing from about 0.1 to 6 weight percent ethylene; and

10 the second homogeneous ethylene/alpha-olefin copolymer comprises a copolymer resulting from the copolymerization of from about 99 to 80 weight percent ethylene, based on total monomer weight, and from about 1 to 20 weight percent of a second alpha-olefin, based on total monomer weight, wherein the second alpha-olefin comprises at least one member selected from the group consisting of butene-1, hexene-1, and octene-1.

12. The multilayer film according to claim 11, wherein:

15 the first homogeneous ethylene/alpha-olefin copolymer consists essentially of a copolymer resulting from the copolymerization of from about 95 to 85 weight percent ethylene, based on total monomer weight, and from about 5 to 15 weight percent of a first alpha-olefin, based on total monomer weight, wherein the first alpha-olefin comprises a member selected from the group consisting of octene-1, and a blend of hexene-1 and butene-1;

20 the second layer comprises a propylene/ethylene copolymer containing from about 0.1 to 6 weight percent ethylene, the propylene/ethylene copolymer being present in an amount of at least 50 weight percent, based on the weight of the second layer;

25 the second homogeneous ethylene/alpha-olefin copolymer consists essentially of a copolymer resulting from the copolymerization of from about 95 to 85 weight percent ethylene, based on total monomer weight, and from about 5 to 15 weight percent of a second alpha-olefin, based on total monomer weight, wherein the second alpha-olefin comprises a member selected from the group consisting of octene-1, and a blend of hexene-1 and butene-1; and

the multilayer film has an  $O_2$ -transmission rate of from about 2,000 to 10,000 cc/m<sup>2</sup>/ 24hr STP.

13. The multilayer film according to claim 11, wherein:

30 the first outer layer makes up from about 10 to 80 weight percent of the multilayer film;  
the inner film layer makes up from about 10 to 80 weight percent of the multilayer film; and

the second outer layer makes up from about 10 to 80 weight percent of the multilayer film.

14. The multilayer film according to claim 13, wherein:

the first outer layer makes up from about 10 to 40 weight percent of the multilayer film;

5 the inner layer makes up from about 20 to 80 weight percent of the multilayer film; and

the second outer layer makes up from about 10 to 40 weight percent of the multilayer film.

15. The multilayer film according to claim 13, wherein:

10 the multilayer film has a total thickness of from about 1 to 3 mils, and an  $O_2$ -transmission rate of from about 3,000 to 6,000 cc/m<sup>2</sup>/24hr STP;

the inner layer comprises a propylene/ethylene copolymer containing from about 2 to 5 weight percent ethylene; and

the first homogeneous ethylene/alpha-olefin copolymer is substantially identical to the second homogeneous ethylene/alpha-olefin copolymer.

15

16. The multilayer film according to claim 15, wherein the film has a total thickness of from about 1 to 2.5 mils, the first outer layer has a thickness of about 0.3 to 0.8 mil, the inner layer has a thickness of from about 0.5 to 1 mil, and the second outer layer has a thickness of from about 0.3 to 0.8 mil.

20 17. The multilayer film according to claim 16, wherein the film has a total thickness of from about 1.5 to 2 mils, the first outer layer has a thickness of about 0.4 to 0.5 mil, the inner layer has a thickness of about 0.6 to 0.8 mil, and the second outer layer has a thickness of about 0.4 to 0.5 mil.

18. A packaging process for packaging an  $O_2$ -sensitive product, comprising:

25 (A) supplying, to a vertical form fill and seal apparatus, a rollstock comprising a multilayer film comprising:

(1) a first outer layer comprising:

(i) at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer; and

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(ii) a surface-active agent comprising at least one member selected from the group consisting of ester of aliphatic alcohol, polyether, polyhydric alcohol, ester of polyhydric aliphatic alcohol, and polyethoxylated aromatic alcohol;

(2) at least one inner layer comprising polyolefin; and

5 (3) a second outer layer comprising at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer;

wherein the surface-active component is present over the entire outside surface of the first outer layer, the at least one inner layer is between the first outer layer and the second outer layer, at least one inner layer is chemically different from the first outer layer and the second outer layer, and the multilayer film has an O<sub>2</sub>-transmission rate of from about 500 to 50,000 cc/m<sup>2</sup> 24hr STP;

10 (B) forming a substantially vertically-oriented tube from the multilayer film, by passing the film over a collar member of the vertical form fill and seal apparatus, so that substantially vertically-oriented edge portions of the film are adjacent one another;

(C) forming a longitudinal seal along at least a segment of the adjacent edge portions of the film, to form a sealed tube segment;

(D) collapsing a lower end portion of the sealed tube segment, and forming a bottom package seal across the collapsed lower end portion of the sealed tube segment, to form a pouch;

20 (E) adding an appropriate quantity of the O<sub>2</sub>-sensitive product to the pouch; and

(F) collapsing an upper end portion of the pouch, and forming a top package seal across the collapsed upper end portion to form a sealed pouch containing the oxygen-sensitive product, whereby a package is formed.

25 19. The packaging process according to claim 18, wherein the O<sub>2</sub>-sensitive product comprises a cut vegetable comprising at least one member selected from the group consisting of lettuce, cabbage, broccoli, green beans, cauliflower, spinach, kale, carrot, onion, radish, endive, and escarole.

30 20. The packaging process according to claim 18, wherein the O<sub>2</sub>-sensitive product comprises a cut vegetable comprising at least one member selected from the group consisting of lettuce, cabbage, green beans, kale, carrot, onion, radish, endive, and escarole, and the film has an O<sub>2</sub>-transmission rate of from about 3,000 to 6,000 cc/m<sup>2</sup> 24hr STP.

21. The packaging process according to claim 18, wherein the vertical form fill and seal machine forms, fills, and seals at least 15 packages per minute, without substantial burn through of the film at the seals.

5 22. The packaging process according to claim 21, wherein the film is sealed at a temperature of from about 70°C to 150°C, and the film exhibits a hot tack strength of from about 4 to 15 Newtons.

23. A package comprising:

(A) an oxygen-sensitive product; and

10 (B) a multilayer film substantially surrounding the product, the multilayer film comprising:

(1) a first outer layer comprising:

(i) at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer; and

15 (ii) a surface-active agent comprising at least one member selected from the group consisting of ester of aliphatic alcohol, polyether, polyhydric alcohol, ester of polyhydric aliphatic alcohol, and polyethoxylated aromatic alcohol;

(2) at least one inner layer comprising polyolefin; and

20 (3) a second outer layer comprising at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer;

wherein the surface-active component is present over the entire outside surface of the first outer layer, and the inner layer is between the first outer layer and the second outer layer, the inner layer is chemically different from the first outer layer and the second outer layer, and the multilayer film  
25 has an O<sub>2</sub>-transmission rate of from about 500 to 50,000 cc/m<sup>2</sup> 24hr STP.

24. A process for heating a package comprising a food product, comprising:

(A) packaging the food product in a film comprising:

(1) a first outer layer comprising:



(i) at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer; and

(ii) a surface-active agent comprising at least one member selected from the group consisting of ester of aliphatic alcohol, polyether, polyhydric alcohol, ester of polyhydric aliphatic alcohol, and polyethoxylated aromatic alcohol;

(2) at least one inner layer comprising polyolefin; and

(3) a second outer layer comprising at least one member selected from the group consisting of ethylene homopolymer, ethylene/alpha-olefin copolymer, ethylene/ester copolymer, ethylene/acid copolymer, and ionomer;

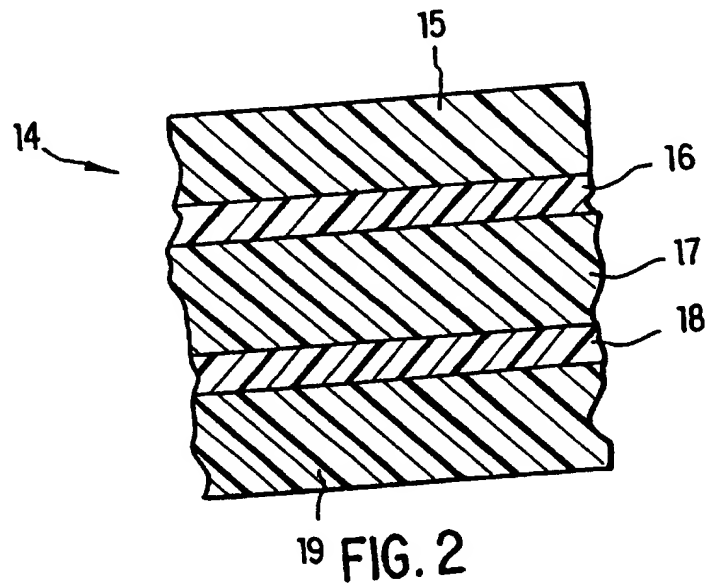
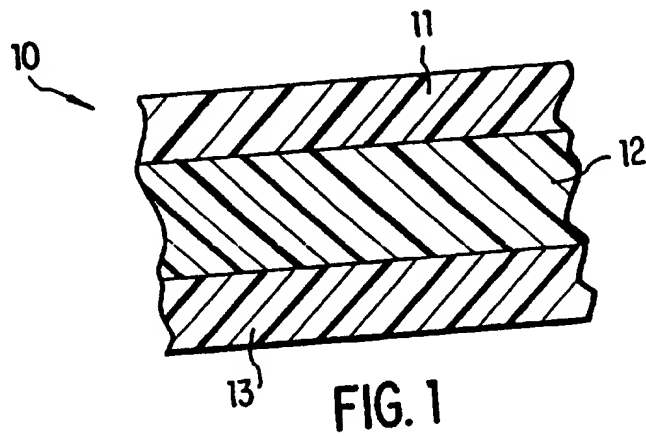
wherein the surface-active component is present over the entire outside surface of the first outer layer, and the inner layer is between the first outer layer and the second outer layer, the inner layer is chemically different from the first outer layer and the second outer layer, and the multilayer film has an  $O_2$ -transmission rate of from about 500 to 50,000 cc/m<sup>2</sup> 24hr STP;

(B) heating the food product and film to a temperature of from about 80 to 212F, for a period of from about 1 to 60 minutes;

wherein the food product is substantially encased by the film, and wherein the film survives the cooking process without substantial loss of package integrity.

25. The process according to claim 24, wherein the food product is cooked during the heating step.

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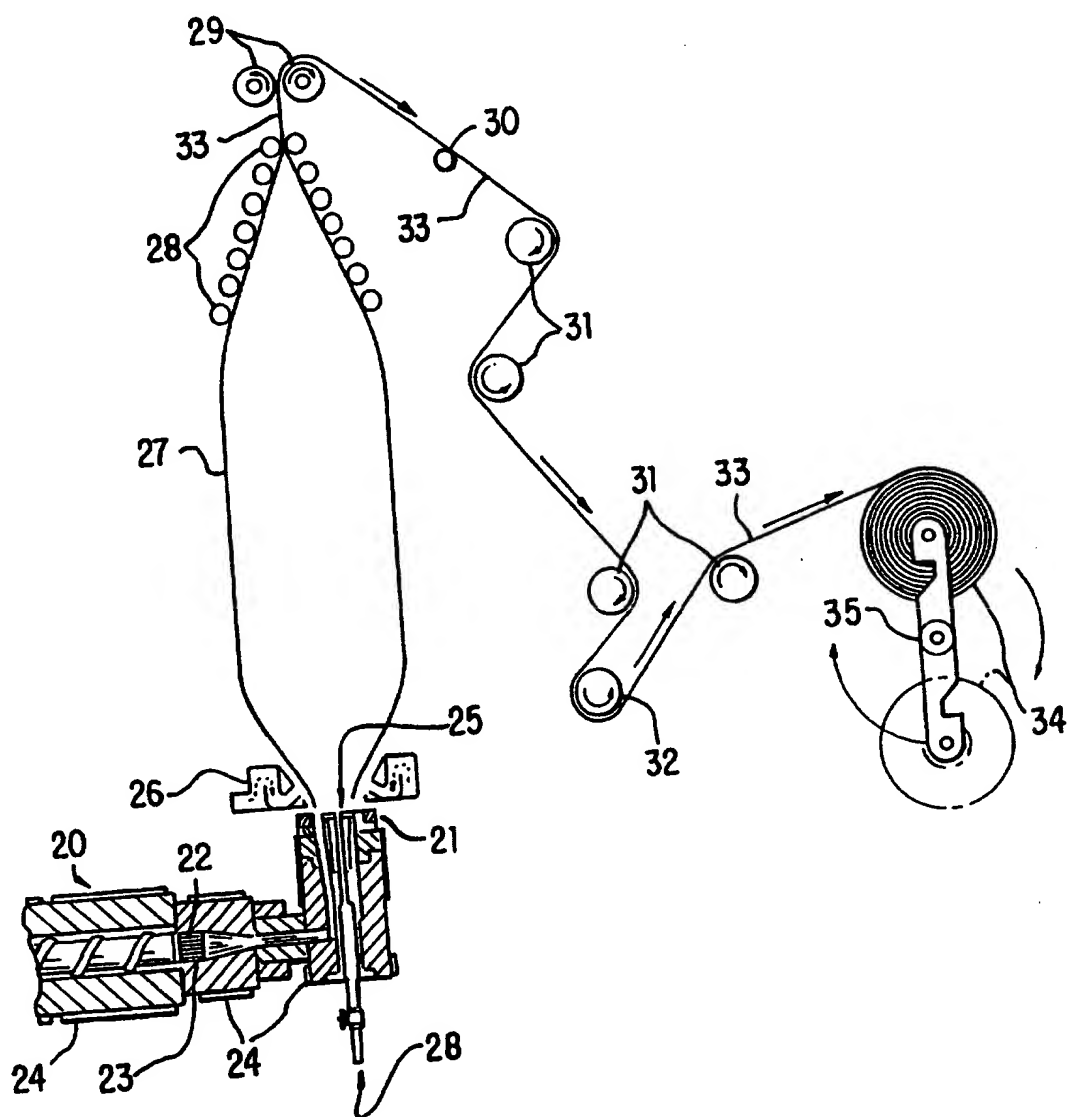


FIG. 3

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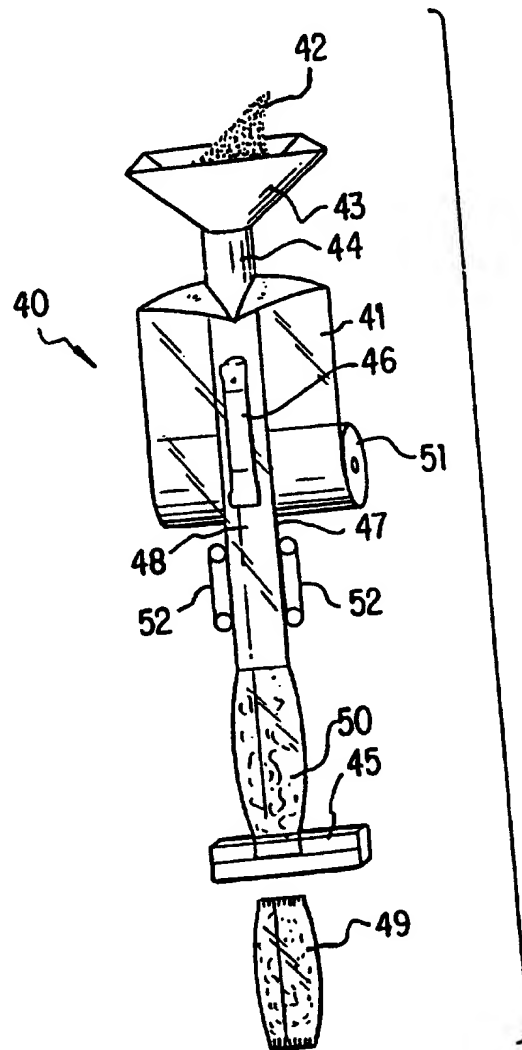


FIG. 4

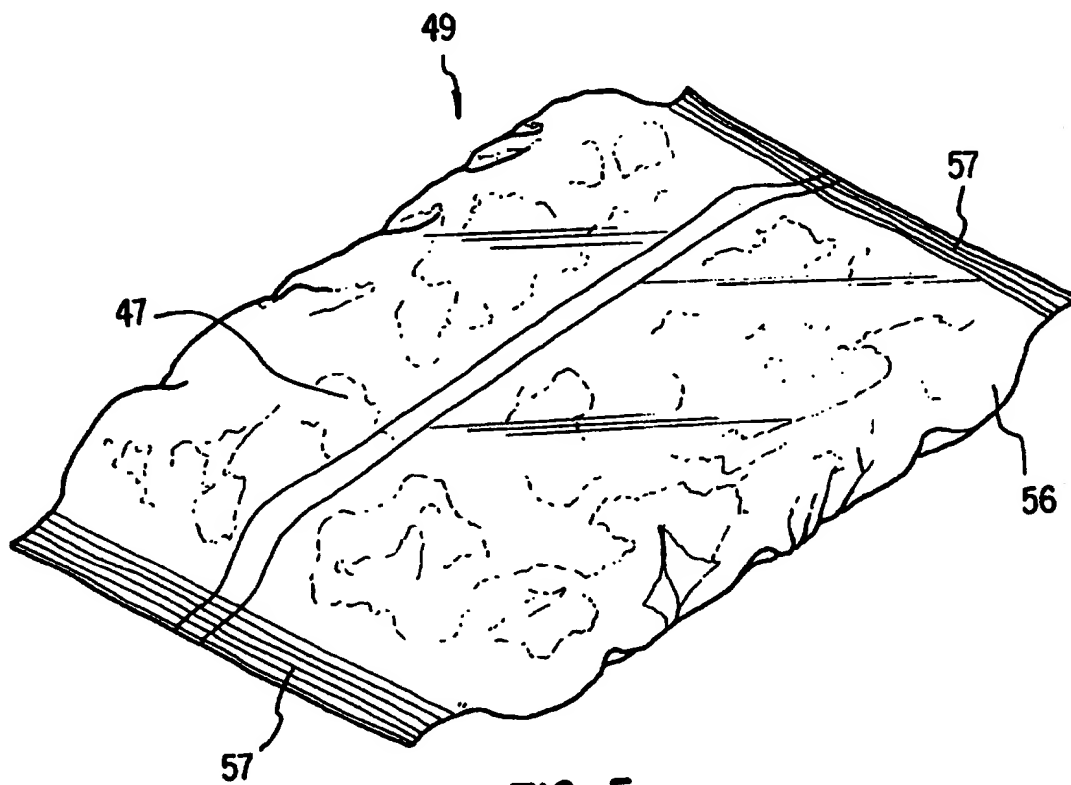


FIG. 5

# INTERNATIONAL SEARCH REPORT

Int. Appl. No.

PCT/US 96/16405

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 B32B27/18 B32B27/32 B65D65/40

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 6 B32B B65D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 243 965 A (TOYO BOSEKI) 4 November 1987 see page 13, line 15 - line 26; claims see page 19, paragraph 2 - paragraph 3 see page 14, last paragraph	1-3,23
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P,X	US 5 427 807 A (CHUM PAK-WING S ET AL.) 27 June 1995 see column 3, line 29 - line 54; table 4 see column 6, line 54 - column 7, line 3 see column 10, line 5 - line 10 see column 15, line 50 - column 16, line 20	1,23
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	-/-	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

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Date of mailing of the international search report

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# INTERNATIONAL SEARCH REPORT

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PCT/US 96/16405

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A	EP 0 580 377 A (SUMITOMO CHEMICAL CO) 26 January 1994 see page 2, line 33 - page 3, line 35; claims; examples see page 4, line 28 - line 33 ---	1-17,23
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